Historic, archived document

Do not assume content reflects current
scientific knowledge, policies, or practices.

Issued July 7, 1909.

U. S. DEPARTMENT OF AGRICULTURE,
FOREST SERVICE—Circular 163.
GIFFORD PINCHOT, Forester.

PAPER BIRCH IN THE NORTHEAST.

By

S. T. DANA,
FOREST ASSISTANT.

WASHINGTON : GOVERNMENT PRINTING OFFICE : 1909

CONTENTS.

Page.
Importance of paper birch 5
  Annual cut 5
  Spool industry 5
  Shoe peg and shoe shank industry 7
  Other industries 8
  Principal markets 9
Distribution of paper birch 10
  Botanical range 10
  Commercial range 10
    Effect of fires and clearings 11
  Types 12
  Stand per acre 14
The paper birch supply 15
Botanical and silvical characteristics 15
  General appearance 15
    Leaves, flowers, and fruit 16
  Wood 16
  Soil, moisture, and light requirements 18
  Growth 19
  Susceptibility to injury 21
  Reproduction 22
    By seed 22
    By sprouts 22
Management 23
  Methods of lumbering 23
    Possible improvements 26
  Systems of management 28
Volume and yield tables 30
Outlook for future supplies 37

ILLUSTRATIONS.

Page.

Fig. 1. Distribution of paper birch in commercial quantities in the Northeast. 12

2. Stack of 4-foot bolts of paper birch for spool stock, showing variation in size of red heart and in size of bolts, 4 to 18 inches in diameter. Piscataquis County, Me. 18

TABLES.

Page.

Table 1. Height and diameter growth 19

2. Volume growth 20

3. Total stem volumes 31

4. Merchantable volumes by diameter and height 31

5. Merchantable volumes by diameter and merchantable length 32

6. Diameters at 5-foot intervals above the ground 33

7. Diameters at 1-foot intervals above the ground 34

8. Solid wood per stacked cord 35

9. Yield of pure paper birch stands 36

PAPER BIRCH IN THE NORTHEAST.

IMPORTANCE OF PAPER BIRCH.

Although paper birch (*Betula papyrifera*) does not rank with the most important hardwoods, it is, nevertheless, a valuable species in the Northeast, and particularly in Maine. In this State it stands second in amount of annual cut of hardwoods, and is exceeded only by the aspens. It is used almost exclusively by a number of woodworking industries, and no satisfactory substitute for it has yet been found in the manufacture of certain articles. From the point of view of the forester also it is a particularly interesting tree, because it grows mainly on burned-over areas, and the present extensive stands of it are due to past fires. This characteristic of occupying burned-over tracts it shares with "popple," with which it is frequently associated. Both species are, in a way, the pioneers of the forest; they occupy the ground only for a short while and prepare the way for the permanent forest type natural to the locality. Yet in spite of the value of paper birch from both an economic and a silvicultural point of view, very little has been published concerning it.

ANNUAL CUT.

The annual cut of paper birch in the Northeast averages about 80,000 cords, or approximately 32,000,000 board feet. The cut has increased but little in recent years, and it is probable that it will not greatly increase. The wood supplies small mills for the most part, and many of them use no other species; even the largest mills seldom use more than 10,000 or 12,000 cords per year. A number of woodworking industries of the Northeast use practically nothing but paper birch, and several others use it almost exclusively. It is made into spools, shoe pegs, shoe shanks, toothpicks, dowels, various wood novelties, and a wide variety of miscellaneous articles.

SPOOL INDUSTRY.

The spool industry is by far the most important of the industries dependent upon paper birch. It uses annually about 43,000 cords, or more than half of the total cut of birch. Spool mills are located throughout the birch region, but the industry may be said to center in the valleys of the Piscataquis and Penobscot rivers in central Maine, where the largest mills are located, and where the birch is used almost entirely for this purpose. For spool manufacture the wood must be sound and free from red heart, coarse knots, mildew, stain, or pith. This means, of course, that only the best of the birch can be utilized and that there is a large waste caused by these defects. This waste is used mainly for fuel, while the slabs and edgings are frequently sold for cord wood to supply city markets, and bring from $3 to $4.50 per cord on the cars.

The various steps involved in the manufacture of the spools from the round log to the finished product are, briefly, as follows: The green logs are brought to the mill during the fall or winter in 4-foot lengths and are first sawed lengthwise into bars, or " squares." These bars are made 4 feet long whenever possible and are square in cross section, of various sizes, depending on the size of the spool desired. The bars must all be sawed out before the 1st of June, preferably before the 1st of May, in order to prevent staining. Round logs with the bark on begin to stain as soon as warm weather sets in, usually about the middle of May. By the middle of June 3-foot bolts are usually stained throughout their entire length, and by the 1st of August 4-foot bolts are entirely stained. Soon after this white streaks begin to appear in the wood and it loses its strength. Whole stems left in the woods stain for only 2 or 3 feet at both ends, but the rest of the material is not so clean and white as when winter-sawed during the first season. Best results are obtained by sawing the wood while it is frozen.

With clear, white birch of the best quality, practically free from large knots and red heart, 2 cords of round logs yield a thousand board feet of spool bars. With the ordinary run of material, however, it takes from 2½ to 3 cords to make a thousand feet of bars. Exceptionally poor material, practically culls, has been known to run 6 cords to the thousand feet of bars. The sawing of the logs into such small bars makes much sawdust waste, and half a cord of sawdust has actually come from a single cord of bolts.

Immediately after sawing, the green bars are stacked in open piles out of doors, but under cover. The air has free access to them, and they usually season for several months. When it is desired to use them, they are put into a dry kiln to complete the seasoning. It is essential that seasoning should be thorough, since the slightest change in the size of the spool after manufacture makes it impossible for the delicately adjusted machines now in use in the cotton mills to wind the thread upon it.

The manufacture of the kiln-dried bars into spools differs slightly in various mills, though the general process is the same. The bars are first cut into short pieces the exact length of the spool desired, and these are then put through a lathe which turns out the spools; in many cases these spool machines are entirely automatic. The best of them work with great speed and accuracy and turn out spools at the rate of one a second.

At this stage the spools are still rough and must be smoothed off so that the thread may not be cut and broken in winding. This smoothing is done by rolling the spools about for half an hour or more, together with several balls of wax or paraffin, in a large, hollow cylinder. This is the general process by which the ordinary sewing spools are made, and they are then sorted, culled, and shipped.

The very large spools, however, must be made in three pieces. A cylindrical piece several inches long and threaded at each end serves as the body of the spool, and the heads are cylindrical disks which are screwed on to the body piece and glued. The spool is then completed by being turned on a lathe and is smoothed and polished with sandpaper. The largest of these three-piece spools hold 12,000 yards of thread, and between them and the smallest ones, that hold only 20 yards, there is every possible gradation in size and shape.

Many substitutes for paper birch have been tried in the manufacture of spools, but so far none has proved wholly successful. Pulp is used to some extent, particularly with large spools, which have also been made with a body of pine and with pulp heads. Sawdust consolidated by hydraulic pressure has been tried, but it is very heavy and is unsatisfactory in other respects. Other woods have been tried, but all have been found wanting as compared with paper birch; they are too hard, or too soft, or do not turn well. Yellow birch is the only species which has met with any favor. It is now used to some extent by a number of mills and there is no distinction on the market between the spools from the two species. Yellow birch is considerably the harder of the two woods, and to get the best results the method of manufacture must differ slightly from that for paper birch. This fact is not always appreciated by the mill men and probably accounts for much of the prejudice they have against yellow birch. When properly handled it seems to give good results, particularly the second-growth material, locally known as "silver birch." The southern hardwoods have not been tried extensively as yet, and it is possible that such species as black gum, red gum, and yellow poplar may prove to be fairly satisfactory substitutes.

SHOE PEG AND SHOE SHANK INDUSTRY.

The next most important use for paper birch after the spool industry is for the manufacture of shoe pegs and shoe shanks. This industry, which uses about 11,000 cords of paper birch annually, is confined entirely to the northeastern United States and, except for a small amount of yellow birch, uses paper birch exclusively.

Shoe pegs are made in two distinct ways. The more usual method is to cut the bolts into small blocks, which are in turn split up into pegs. The other method is to cut the bolts into peg "ribbons." These are manufactured at only two places in this country—or probably in the world, for that matter—at Conway, N. H., and Brownville, Me. The round bolts are first cut into short pieces, usually 25½ inches long, and the bark peeled from them. The peeled bolts are then put into a machine which revolves them against a series of sharp knives, which cut off veneers of the width and thickness of the pegs. These veneers are in the form of long, narrow ribbons, and are cut under considerable pressure so that much of the sap is forced out of them. They are next run through a machine which puts one sharp edge on the ribbons, and finally through a third machine which heats, compresses, and toughens them. They are shipped in the ribbon form and are cut into pegs with an automatic machine when used by the cobbler. A marked difference between this process and that used in making spools is that in this case the wood is seasoned when the article is turned out rather than before. In the manufacture of peg ribbons, even more than in the manufacture of spools, it is imperative that only the very best wood be used. Red heart has to be entirely discarded, knots unfit the wood for use, and the bolts must be of fairly good size. Consequently peg wood frequently costs $15 per cord at the mill, while spoolwood usually costs only $5 or $6.

Shoe shanks, which are used in the insteps of some shoes between the heel and the broad part of the sole, are usually manufactured in connection with shoe pegs. They also require fairly clear, white wood, but not necessarily of so high a quality as for shoe pegs. They are first cut from the peeled bolts as veneers, which are later cut by an automatic machine into finished shanks of various sizes. These are neither polished nor seasoned and are shipped loose in large sacks.

OTHER INDUSTRIES.

The greater part of the toothpicks used in this country are manufactured in the Northeast, and, with the exception of a few hundred cords of poplar and maple used for this purpose, are there made entirely from paper birch. Approximately 3,000 cords of birch are consumed annually in their manufacture. The stock from which they are made must be free from knots and red heart, straight, and preferably over 9 inches in diameter. In other words, only the very highest grade material can be used. This material is usually selected from stock which is being cut for other purposes, and sells for from $15 to $25 per cord at the mill. The logs are first cut into 2-foot bolts, peeled, steamed slightly to take out the frost, and then run through a veneer machine, which cuts off a thin veneer the length and thickness of the toothpick. From these veneers the toothpicks are automatically cut out, thoroughly dried, and sometimes polished.

Dowels, toys and novelties, and various miscellaneous articles, such as clothespins, hairpin boxes, bobbins, and shuttles, consume annually about 23,000 cords of paper birch. These industries all differ considerably from those previously described in that they use considerable quantities of other woods than paper birch. Chief among these are yellow birch, sugar maple, and beech. These articles can also in many cases be made of an inferior grade of birch. A small per cent of red heart is usually allowed in most dowels, and cheap toys and novelties are not infrequently made entirely from red heart and knotty wood which could not be used for any other purpose. This fact is sometimes taken advantage of by combining spool and novelty mills, so that the novelty mill can be largely supplied by the waste from the spool mill.

PRINCIPAL MARKETS.

The principal market for paper birch and its products is in this country, although there is some export business. The spools are mainly manufactured near the source of the timber supply and are then shipped to the thread mills in various parts of the country, chiefly to Rhode Island, Connecticut, New Jersey, and, to some extent, to California.

The shipment of spool bars to Scotland is, however, an important part of the trade and these shipments now amount annually to about 4,000,000 board feet. Scotland has always been a heavy consumer of birch for spools, and when the immediately available supply of European birch (*Betula alba*) began to fail, the manufacturers turned to this country to supply their demands. The first shipment of bars abroad was made to Scotland in 1882 from Bangor, Me., and since then shipments have continued, but with considerable fluctuation. The largest shipments were made in the latter part of the nineties and in one year ran as high as 13,000,000 board feet. Recently they having been decreasing until they now amount to only 3,000,000 or 4,000,000 board feet annually. This falling off is due to two causes: First, manufacturers abroad do not pay high enough prices to attract small dealers into the business; and, second, large tracts of European birch in Finland and the Scandinavian countries are now becoming available. This European white birch, while not of such high quality as the paper birch of this country, can, nevertheless, be used for spools and is cheaper because of its nearness and because of the lower wage scale in those countries.

Other paper birch products are mainly manufactured near the source of supply and are marketed, for the most part, in this country. Shoe pegs, and to a lesser extent shoe shanks, are, however, sent in considerable quantities to Germany, to Japan, and to other countries. Quite recently shipments of toothpicks have been made to England, France, and Germany. In all, the manufactured equivalent of about 12,000 cords of paper birch, or approximately one-seventh of the total cut, is exported annually.

DISTRIBUTION OF PAPER BIRCH.

BOTANICAL RANGE.

Paper birch is one of the most widely distributed trees of North America. It was formerly thought to be transcontinental in range, but the western forms are now divided into two distinct, although closely related, species. Of these *Betula alaskana* grows in Alaska, and *Betula occidentalis* in southwestern British Columbia and northwestern Washington.

Paper birch proper extends from Maine and Labrador northward almost to the Arctic Circle and westward to the Rocky Mountains and the valley of the Mackenzie River in British Columbia. It is decidedly a tree of the north and has been found as far as latitude 65° N., a point nearly as far north as is reached by any broadleaf tree of North America. In the United States it is found only along the northern border, and its southern limits are Long Island, northern Pennsylvania, central Michigan, central Iowa, and northern Nebraska. Its western limits are as yet imperfectly defined. In the southern part of its range it is small and comparatively rare, and never attains the commercial importance that it does farther north, where it is more at home.

COMMERCIAL RANGE.

In spite of its wide range paper birch is, in most places, not an abundant tree. It is scattered through forests of other trees and pure stands of any size are rare. In the United States the only extensive stands are in the Lake States and in northeastern New England. In the Lake States there are several belts of it on burned-over areas, but these stands are not, as a rule, fully stocked. The birch is short, branchy, and usually of poor quality for anything except fuel. Minnesota contains the largest and best stands in this region, and there are localities where this birch, now considered worthless, might be utilized to good advantage. Northern New England, on the other hand, has extensive stands, some of them practically pure, in which the birch is of excellent quality. New England is, therefore, the only part of the United States in which paper birch is at present of commercial importance, and it is there one of the most valuable hardwoods in the forest.

The distribution of the birch in commercial quantities through this region is shown on the map (fig. 1). This does not indicate that the birch is not found outside of the areas marked. It grows throughout all three of these States, and occasionally in sufficient quantities to be cut in southern Vermont and New Hampshire and in other parts of Maine. The map simply shows in a general way what may be called the paper birch region of the Northeast—that is, the region in which it occurs extensively over large areas. Not all of the area is covered exclusively with paper birch. Other species are found everywhere, and there are tracts in which the birch is entirely wanting. To eliminate these tracts and to show exactly where the birch is predominant is impossible in a map of this character, so that only the general outlines of the birch region are shown. Much of the timber in this region is already of sufficient size to be merchantable, but young growth is also found in many places.

Maine is plainly the paper birch State of the country. Vermont has about 300,000 acres of birch land in the north central part of the State, New Hampshire has approximately 570,000 acres in the northeastern part, while Maine has over 5,500,000 acres extending in a broad belt directly across the central part of the State.

EFFECT OF FIRES AND CLEARINGS.

The abundance of paper birch throughout this entire region is due to fires, and in many cases the boundaries of the region correspond exactly with the boundaries of these fires. So intimate is this relation between paper birch and cleared or burned-over areas that it is fairly safe to assume that areas containing a good stand of birch have either been burned or previously cultivated. The reverse, however, is not always true; burned areas are not always occupied by paper birch. Aspen is equally quick to seize upon them, white pine is more or less characteristic of such situations, and still other species may occupy them, though less frequently. Paper birch readily occupies burned or cleared areas, because its seeds are produced abundantly each year and are easily carried to great distances by the wind, so that they are always on hand to restock open areas. The bare mineral soil exposed by burns offers an ideal germinating bed, and the full light gives the young seedlings an excellent chance to develop without danger of being shaded out.

The greatest fire known in Maine occurred in October, 1825. This is generally called the "Miramichi fire," although it was quite distinct from the famous fire of that name which occurred in New

Brunswick the same year. It covered in the neighborhood of 1,300 square miles, and burned over practically all of the area shown on the map from Monson and Abbott east to the Penobscot River. This area now contains some of the heaviest and best stands of birch in the State. The irregular detached section to the north is the result of two fires. The upper part was burned over in 1837, and the lower at some time between this and the great conflagration of 1825. This section, too, contains many excellent stands of birch which are now yielding valuable lumber.

East of the Penobscot River is a large area in Hancock and Washington counties, shown by vertical lines on the map, which is intermediate in character, and its inclusion in the birch region might be questioned. This land has practically all been burned over, parts of it several times. In places it is still barren, while in other places there is good second growth composed of a mixture of many species. Paper birch grows throughout the area, but not so generally in the pure stands that are characteristic of it on other burns to the west. Here the white, or gray birch (*Betula populifolia*), so plentiful in southern Maine and along the whole New England coast, but practically lacking in the rest of the birch region, is abundant. Included within this territory is a tract surrounding Grand Lake which contains good stands of mature paper birch, and should undoubtedly be classed with the region west of the Penobscot.

In western Maine the bounds of the different fires are not so well marked, but a large part of the territory was probably burned over about 1825. The best stands here are to the south and east of the Rangeley Lakes, where they fully equal those in central Maine. Along the line of the Grand Trunk Railroad in the neighborhood of Bryants Pond, Lockes Mills, and Bethel, the birch has been cut very heavily for many years; the original supply has been almost exhausted, but there is now more or less second growth available.

In New Hampshire and Vermont fires have also been responsible for the creation of paper birch tracts, but not to such an extent as in Maine. The stands are more scattered and the yield, as a rule, not so heavy. Much of the timber is already mature, but there is also much young growth.

TYPES.

Paper birch stands may be divided according to their composition into two general classes—pure and mixed.

Pure stands are not so abundant as mixed, but they are of greater commercial importance. These stands vary in extent from a few to several hundred acres, and contain from 75 to 90 per cent of birch. The principal species found in mixture in such stands are the two

Lake Champlain

Circ. 163, Forest Service, U. S. Dept. of Agriculture.

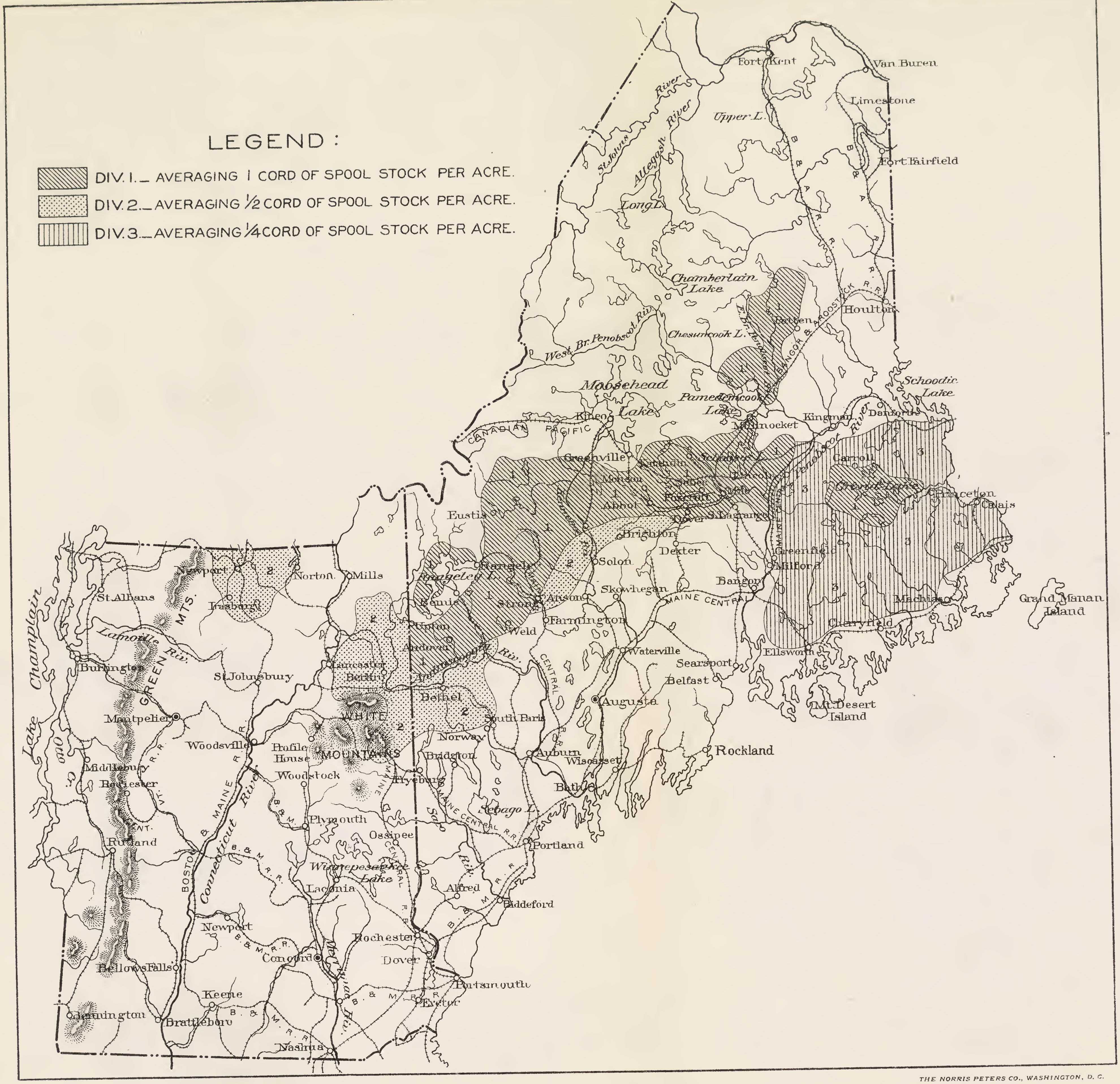

FIG. 1.—Distribution of paper birch in commercial quantities in the Northeast.

THE NORRIS PETERS CO., WASHINGTON, D. C.

aspens, often with an understory of spruce and balsam. These stands are generally even-aged, and have a fairly uniform crown cover. There are usually a few large-crowned, sprawly individuals which obtained an advantage at the outset and have developed abnormally, and also a few badly crowded, suppressed, and dying individuals; but the main stand consists of trees of approximately the same degree of development with rather narrow, medium-sized crowns. In mature stands the crown cover is not continuous, but is more or less open and broken in places, owing to the intolerance of the birch. This enables such tolerant species as spruce and balsam, which are able to start under the light shade cast by the birch, to develop more rapidly and eventually to establish themselves as the permanent forest type.

In mixture paper birch occurs in three quite distinct ways—with aspen, with other hardwoods, and with conifers. Mixed stands of birch and aspen closely resemble pure birch stands in general character and appearance. The two species may be present in practically equal numbers, or one or the other may slightly predominate. There is the same even-aged, even-crowned character of the pure birch stand, except that the aspen often shows larger and taller individuals than the birch. The stands begin to break up at about the same age and to deteriorate in much the same way.

When paper birch is mixed with other hardwoods its principal associates are yellow birch, sugar maple, and beech. These stands differ considerably from pure birch stands. They are often irregular and not even-aged, and evidently start as a more or less open mixed stand in which paper birch is prominent. Then more tolerant species gradually come in and fill up the blanks, so that the stand assumes somewhat the character of a virgin forest with various age classes present. Paper birch in such stands usually develops a spreading crown, a large diameter, a knotty bole, and a comparatively short merchantable length. The tree is likely, however, to have a large proportion of clear, white sapwood and to remain sound longer than when in pure stand. Stands of this character, when the birch has once been cut or has died out, usually revert to the mixed hardwoods type.

Mixed stands of paper birch and conifers, usually spruce and balsam, have still a different character. In these the birch and conifers usually take possession of the ground at the same time, although the conifers may be a few years later in making their appearance. The birch, however, makes a very much more rapid height growth in early youth and soon overtops the conifers, so that the stand has the appearance of a two-storied forest, the birch occupying the upper story, with plenty of space and light in which to develop. The spruce and balsam are tolerant and thrive under the relatively light shade. Their growth is more persistent and well-maintained than that of the birch, and in time they overtake it. The exact age at which they do this varies considerably, but as a rule the conifers catch up with the birch enough to make a closed stand in from forty to sixty years. The birch is then crowded from the sides, prunes itself well, and develops a clear bole with good merchantable length. As a result, the best developed trees with the best quality of wood are often found in mixture with spruce and balsam. It is sometimes claimed that there is more red heart in birches grown in mixtures of this kind, but this seems to depend more on the character of the soil than on the mixture. Upon the removal of the birch there results a pure coniferous type.

STAND PER ACRE.

The stand of paper birch varies very greatly in different places, and under different conditions, from almost nothing up to 40 or 50 cords per acre. Even experienced woodsmen are likely to overestimate the average stand. Actual figures of the cut of spool stock, which may be taken as a fair representation of the merchantable material, from two good birch towns in Maine are, respectively, 58,175 cords from 18,000 acres, or an average of 3.2 cords per acre; and 39,905 cords from 10,000 acres, or nearly 4 cords per acre. The northwest corner of the second town, where the birch was exceptionally thick, yielded 16,500 cords from 3,000 acres, or an average of 5.5 cords per acre. Still another town, which was considered rather poor but still good enough to cut, yielded only 3,303 cords from 6,000 acres, or an average of 0.55 cord per acre. All the material may not have been completely utilized in these cases, but it was approximately so, since the towns were cut over with considerable care.

Actual cuts and careful estimates show that the average stand in what are ordinarily considered good birch towns is about 2 cords of spoolwood material per acre. Individual acres may, of course, run very much higher than this, and single exceptional acres may run as high as 40 or 50 cords. Areas of a few hundred acres may average as high as 12 or 15 cords of spool stock per acre. Still other areas, even within the birch region, contain no paper birch whatever. It is, therefore, fair to assume that within the better portion of the birch region (marked 1 on the map) the stand will average 1 cord per acre; in the intermediate portion (marked 2 on the map), one-half cord per acre; and in the poorer portion (marked 3 on the map), one-quarter cord per acre. All these figures refer to the quantity of spool stock and not to the total amount of solid wood per acre, which would probably overrun these figures by about 20 per cent, and, therefore, give a considerably larger stand. Most of the birch stands, however, are now so remote from the market and the difficulties of transportation are so great that it is impracticable to utilize this additional 20 per cent, which, if more accessible, would be valuable for fuel.

THE PAPER BIRCH SUPPLY.

No attempt has ever been made to secure an accurate estimate of the total amount of paper birch in the Northeast. The birch is so widely and so irregularly scattered over a large area that this would be a very difficult undertaking. At the same time, it is possible to estimate roughly the present supply, how long it will last, and what will be the source of future supplies. In the three divisions shown on the map (fig. 1), as already explained, division 1 is assumed to contain 1 cord per acre of merchantable material; division 2, one-half cord per acre; and division 3, one-quarter cord per acre. The application of average figures to so large an area is not wholly satisfactory, but it is the best method that can be used under the circumstances, and the resulting estimate is at least conservative. If these average figures are multiplied by the total area of each division the result gives a total stand of approximately 4,000,000 cords of merchantable paper birch.

Even with an assumed annual consumption of 100,000 cords, as against the present actual average of 80,000 cords, there is now standing a sufficient supply of birch to last for forty years. This, of course, does not take into consideration the increase through growth of existing stands, or through young growth which will mature during that period. On the other hand, much of the supply is not at present accessible, and a considerable part of it is also deteriorating because of old age. Taking everything into consideration, however, it is certain that users of paper birch will not feel the pinch of a shortage so early as will the users of many others of our important trees.

BOTANICAL AND SILVICAL CHARACTERISTICS.

GENERAL APPEARANCE.

Mature paper birch may be readily recognized by its creamy white bark, which separates readily into thin, papery layers. Small twigs, and the stems of young trees up to an inch or two in diameter, have a brownish bark, usually tinged with orange, while near the ground on old trees the bark often becomes dark, blackish, and broken into thick, closely appressed scales. The bark not infrequently resembles that of the white birch, but can be distinguished from it not only by its greater whiteness and scaliness, but also by the fact that white birch has at the base of the limbs dark, triangular patches which paper birch does not have. Intermediate forms occasionally occur in which the bark resembles that of both species. Such specimens are sometimes looked upon by woodsmen as hybrids. They appear, however, to be merely variations from the type, due to different conditions of site and growth, and can be readily classified by their leaves and other characteristics.

Forest-grown paper birch has a long, clear bole with a narrow crown occupying usually a little less than half the length of the tree. The twigs are fine and delicate and the foliage very light and open. The open-grown tree is usually shorter with a much shorter bole and a much larger, better developed crown.

LEAVES, FLOWERS, AND FRUIT.

The leaves of paper birch are ovate, irregularly serrate, with short, broad points which distinguish them at once from the very long-pointed leaves of the white birch. The winter buds are dark chestnut brown, ovate, acute, and about one-fourth inch long. They help to distinguish the tree from white birch, since they and the twigs on which they grow are slightly hairy, while in white birch they are smooth.

The birches are all monœcious, having the staminate and pistillate flowers on the same tree. The staminate flowers occur in long catkins, or aments, which are visible during the winter and elongate and bloom in early spring. The pistillate flowers occur in much shorter aments and are not visible during the winter. They form a cone-like fruit, or strobile, on the scales of which are borne the seeds. These are very small and light, equipped with thin, membranous wings, which are much broader than the seed itself, so that the seed is easily carried long distances by the wind.

WOOD.

The wood is of medium weight, fairly hard, strong, and tough, of close grain and uniform texture. Green wood contains considerable sap and is rather heavy and hard to handle. When seasoned, however, it becomes fairly light and has a specific gravity of 0.59 and a weight of 37 pounds per cubic foot. The wood is usually straight-grained, although cross-grained individuals occasionally occur, particularly on exposed north slopes. It varies more or less in toughness and its character in this respect can frequently be judged from the appearance of the bark. Dark-colored, close-barked trees are apt to have a tough, stringy wood, while those with a very white, papery bark scaling off in large plates are apt to have a smooth, easily worked wood. The wood is not durable and decays quickly in contact with the soil. The bark lasts much longer, and logs are not infrequently found which appear at first sight to be perfectly sound, but which are really a mass of decayed punk inside of the sound bark.

The character of the wood unfits it for certain uses. It is too hard and heavy for ordinary construction timber, is too soft for hardwood lumber, and is not striking enough in appearance to be popular for furniture or interior finish. It is too perishable to be fit for ties, posts, fence rails, or other uses in the open. In the Lake States it has nevertheless been used to some extent as ties for logging railroads, where these were not expected to last more than two or three years, and then left in the ground to rot. It is possible that preservative treatment may open a new field for its use, but without such treatment its utilization in the open must be very limited. It is a little used for the manufacture of paper pulp and is fairly satisfactory, but will hardly be much used for this purpose because of its comparative scarcity and of the difficulties of transportation.

On the other hand, the even grain and uniform texture of the wood, its ability to hold its shape after seasoning, the ease with which it turns on the lathe, and the smooth, clean surface which it presents particularly adapt it to a number of wood-working industries where accuracy and nicety of finish are required, such as the manufacture of spools, shoe pegs, shoe shanks, dowels, toothpicks, and various wood novelties.

A serious defect in the wood is that known as "red heart," which materially reduces the quality, strength, and value of the wood and renders it unfit for spool, shoe peg, or toothpick stock; its presence in large quantities means heavy loss. Red heart is not a disease and is not present in very young trees. It is simply the natural heartwood formed with advancing age, and is therefore certain to come in all trees. The age at which it makes its appearance varies greatly. Locality is one of the chief influences. In favorable localities seedlings under 5 or 6 inches in diameter and less than 40 or 50 years old seldom show any red heart. In unfavorable localities and in sprouts it may appear much earlier. With trees over 5 inches in diameter it averages slightly over 6 per cent of the volume of the tree. It does not seem to vary with any set rule, however, and aside from age it is often difficult to determine the exact causes which produce it. When it first appears it usually increases in diameter at about the same rate that the tree is growing, but later spreads more rapidly and encroaches on the white sapwood. Mature trees usually show from 2 to 4 inches of sapwood outside of the heartwood. The heartwood has the same general shape as the tree itself and decreases in diameter from the base up in about the same proportion as the bole, so that there is none in the upper part of the tree.

When the heart first appears it is sound and may remain so for many years or may decay very soon, depending on the locality and the general health of the tree. In an average stand, at maturity, perhaps 10 or 15 per cent of the trees are affected by heart rot, but as soon as the stand becomes overmature the proportion increases very rapidly.

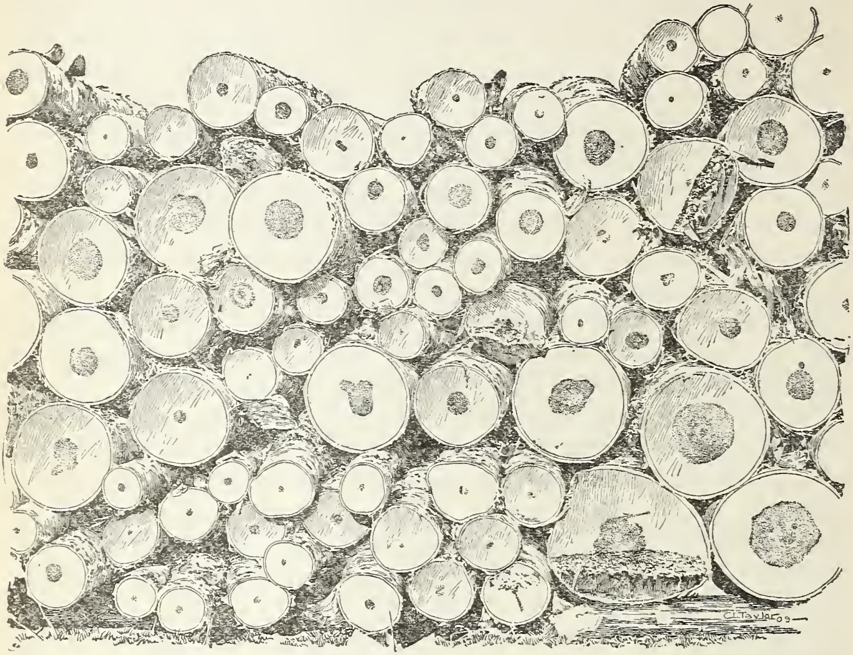

FIG. 2.—Stack of 4-foot bolts of paper birch for spool stock, showing variation in size of red heart and in size of bolts, 4 to 18 inches in diameter. Piscataquis County, Me.

SOIL, MOISTURE, AND LIGHT REQUIREMENTS.

Paper birch is not particularly exacting in respect to its demands upon soil and moisture. It prefers a fairly deep, loose, well-drained, sandy loam, and attains its best development on soils of this character. It is not likely to grow on dry, sandy barrens or in submerged swamps, but is found in practically all situations intermediate between these two extremes. In the White Mountains it is abundant on the thin-soiled rocky slopes above 3,000 feet. This is not, however, because it prefers such situations, but because it is able to grow there while many other trees are not. On Mount Washington it has been found at an elevation of 5,700 feet as a prostrate shrub.

In its light requirements paper birch is much more exacting. It is one of the most intolerant species of the Northeast, and in this respect is exceeded among the broadleaf trees with which it associates only by the aspens. Young seedlings will grow under very light shade but will not survive under a crown cover as dense as that usually found in virgin forests. Saplings and poles when shaded from the side will sometimes struggle along for a while as poorly developed, suppressed individuals but must have absolutely free crowns in order to thrive. Suppressed trees do not recover after being released from suppression, as do spruce and balsam.

GROWTH.

Paper birch is commonly considered a very rapid grower. To some extent this reputation is deserved, though the tree's growth throughout life is not so rapid as is often supposed. It makes a quick start in early youth and shoots up more quickly than most of the species with which it grows, and in this way attracts attention. After the first five or ten years it also makes a good diameter growth, but the rate begins to fall off when the tree is about 30 years old, and gradually decreases until in old age it is almost negligible. Perhaps another reason for the prevalent notion that paper birch is such a rapid grower is the fact that much smaller specimens can be utilized than with other trees lumbered in the region, such as spruce, pine, balsam, and hemlock.

In any consideration of growth a distinction must be made between seedlings and sprouts, and the locality must also be taken into consideration. Table 1 shows the growth of both seedlings and sprouts in height and in diameter, while Table 2 shows their volume growth. The figures for the seedlings are based on 50 full stem analyses of trees growing in low, rocky ground near the shore of Hardy Pond in Piscataquis County, Me. Those for the sprouts are based on 30 full stem analyses of trees growing on a very rocky, rather thin-soiled hillside in Carroll County, N. H. Both localities are of the second quality and represent very well average conditions. These figures should, therefore, give a good idea of the average rate of growth of paper birch throughout Maine and New Hampshire.

TABLE 1.—*Height and diameter growth of paper birch.*

Age.	Height.		Diameter breast-high.	
	Seedlings.	Sprouts.	Seedlings.	Sprouts.
Years.	*Feet.*	*Feet.*	*Inches.*	*Inches.*
5	5	10	0.2	0.7
10	13	19	1.1	1.8
15	22	28	2.2	2.9
20	30	36	3.4	4.0
25	37	43	4.4	4.9
30	44	49	5.3	5.6
35	49	55	6.1	6.3
40	54	60	6.8	6.9
45	58	65	7.5	7.5
50	62	70	8.0	7.9
55	65	74	8.5	8.4
60	68	78	8.9	8.8
65	71	82	9.3	....
70	74	....	9.7	....
75	76	....	10.0	....
80	78	....	10.2	....
85	80	....	....	....
90	81	....	....	....

Table 2.—*Volume growth of paper birch.*

Age.	Total stem volume.		Annual rate of growth.[a]		Volume, N. H. rule.	
	Seedlings.	Sprouts.	Seedlings.	Sprouts.	Seedlings.	Sprouts.
Years.	*Cu. ft.*	*Cu. ft.*	*Per cent.*	*Per cent.*	*Bd. ft.*	*Bd. ft.*
20	....	1.8	....	14.0	....	....
25	2.3	3.2	11.0	9.0	....	13
30	3.6	4.6	7.9	6.3	16	19
35	5.2	6.1	6.3	5.0	22	26
40	6.9	7.7	5.2	4.3	29	34
45	8.6	9.5	4.3	3.8	37	43
50	10.5	11.4	3.6	3.4	46	52
55	12.3	13.5	3.0	3.0	55	61
60	14.1	15.5	2.5	2.7	64	71
65	16.0	....	2.1	....	73	....
70	17.7	....	1.8	....	82	....
75	19.3	....	1.5	....	90	....
80	20.7	....	1.3	....	97	....

[a] The rate of growth given in this table was determined by dividing the increase in volume during the different five-year periods by the volume at the beginning and at the end of the period and by averaging the results obtained to find the rate of growth at the middle of the period. This gave the rate of growth for the five-year period, which was divided by 5 for the annual rate of growth. These values were then plotted on cross-section paper and smoothed off by means of a curve.

It is evident from these tables that the height growth of the sprouts is more rapid throughout life than the height growth of the seedlings. The difference between the two is relatively greater in early youth, but absolutely is about constant.

The difference in diameter growth is not so constant. Up to 45 years of age the sprouts have a greater diameter than the seedlings, at 45 the diameter is the same, while after that the seedlings have the greater diameter. In other words, while the sprouts make a greater diameter growth at first, this rate is not maintained, and the seedlings gradually overtake and pass them.

In volume the sprouts surpass the seedlings throughout life. The difference is not great at any point, and averages only a little more than 1 cubic foot. It is enough, however, to indicate that the encouragement of second growth sprout stands may often be advantageous, particularly for short rotations and when large-sized material is not specially desired. The decrease in rate of growth of both seedlings and sprouts with advancing age is partly counterbalanced by the better quality of the wood, which, on account of its freedom from knots, is much more valuable than the earlier growth. After 55 years of age, however, the rate of growth falls below 3 per cent, so that further growth of the stand is hardly profitable in spite of the increased value of the wood. With very old trees averaging about 20 inches in diameter the annual rate of growth is only 1 per cent.

Paper birch is a comparatively short-lived tree. It matures early and goes to pieces rapidly thereafter. This characteristic varies according to local conditions, and trees on good soils live longer than those unfavorably situated. In general, seedling paper birch is mature at from 70 to 85 years, and seldom lives more than 150 or 200 years. Sprouts are much shorter-lived and usually mature at from 50 to 60 years, and live only from 70 to 90 years. In pure stands birch matures and decays earlier than when in mixture with other hardwoods or with conifers.

SUSCEPTIBILITY TO INJURY.

By far the worst enemy of paper birch is fire. Young seedlings and saplings are destroyed by light ground fires, while even older trees with their thin and highly inflammable bark may be seriously injured or even killed. Severe fires are almost sure to destroy the entire stand.

Although paper birch is not deep-rooted it is nevertheless comparatively free from windfall. This is probably due chiefly to two causes: The root system, although relatively shallow, has a considerable lateral extent and affords good support to the tree; and the slender twigs and branches bend readily before the wind, and therefore offer but little resistance to it.

Living trees are sometimes attacked by a flat-headed bark borer (*Agrilus anxius*), and by the birch bark beetle (*Xylococcus betulæ*), and are defoliated by several kinds of caterpillars. A number of species of beetles destroy the wood of felled trees.

Fungi are a secondary enemy. Live trees are occasionally attacked by *Fomes igniarius* and one or two other shelf fungi, but these attacks are not serious. Dead trees, on the other hand, are attacked at once by *Polyporus betulinus* and other fungi, and decay very rapidly.

In many places deer play havoc with young birch. They are fond of browsing on the winter buds and tender new shoots and not infrequently destroy enough young sprouts and seedlings to interfere seriously with reproduction.

Among the minor enemies of the birch are the sapsuckers, which occasionally bore holes into it. This injury is not very widespread, however, and is rendered less serious from the fact that it is usually confined to the upper part of nearly mature trees. Old trees are seldom injured by frost or drought. Young sprouts, especially those which start in midsummer, may be killed back by early fall frosts, but only the tips are injured, and the plants seldom killed. The collection of birch bark for cups, baskets, and other fancy and ornamental articles is responsible for the death of many trees. Careless collectors frequently girdle trees in the neighborhood of summer resorts, and many dead trees can be found standing as a memorial to their work. A little care in taking only small sections of the outer bark might prevent much of this injury.

REPRODUCTION.

BY SEED.

Paper birch is a prolific seeder. There are no definite seed years as with many other species, and a considerable amount of seed is borne each year. Individual trees may not bear equally heavy crops year after year, but when one has a light crop, another may have a good one, so that the amount of seed produced annually is fairly constant. The germinating per cent is not very high. A sample count showed the fertility by inspection to be 68 per cent. A germination test, even in the greenhouse, would probably give a much lower figure than this, and under natural conditions the proportion of seeds which succeed in germinating would undoubtedly be still further reduced. The best seed is produced in greatest amount by full-crowned trees similar to those found in the open.

The seeds are very light. A sample count of seeds collected in Maine in 1905 showed that there are more than 38,000 seeds to one ounce. This lightness coupled with their wings enables them to be carried readily to great distances by the wind. This accounts for the exceedingly wide distribution of the birch and for its sudden appearance in dense stands on burned or cut-over areas even when there is not a single seed tree in the immediate vicinity. The seeds are not, as is sometimes mistakenly assumed, already in the ground, but are blown in by the wind, which is by far the most important factor in their distribution.

The best germinating bed is a bare mineral soil. A heavy ground cover of leaves, duff, sod, or other material checks the reproduction and in many cases prevents it altogether, since the root system of the young seedlings is decidedly shallow and weak and can not force its way through any thick covering into the mineral soil, so that the tiny rootlet dries up and dies. The shallowness of the root system indicates that the soil must be fairly moist to afford a good germinating bed. Bare mineral soil, capable of holding at least a moderate amount of water, usually characterizes burned-over areas, and this, with the absence of overhead shade, explains the abundant and satisfactory reproduction on old burns.

BY SPROUTS.

Up to a certain age paper birch reproduces itself as readily by sprouts as by seed. The stumps send up from the root collar vigorous shoots, which make a rapid growth during their first few years. Sample counts of 1-year-old sprouts from stumps of 40 to 50 year old trees in New Hampshire showed an average of 46 sprouts per stump, with an average height of slightly over 2 feet. Most of these are soon killed off in the struggle for existence, and usually only from 2 to 4 survive to reach maturity. The old stump decays in a few years, but the sprout origin of the trees may be recognized from the way in which they stand in small clumps. Mature or nearly mature birches do not sprout so freely nor so vigorously as when younger, and in old age probably lose their sprouting capacity altogether. This loss in vigor ordinarily begins at from fifty to sixty years. Consequently, if satisfactory sprout reproduction is desired, the trees should be cut not later than this. The same stump will not produce sprouts for any great length of time, since it eventually becomes exhausted.

As a rule birch stands are composed either entirely of seedlings or entirely of sprouts. Occasionally, however, the two forms are found together in practically even-aged stands. In such cases it is probable that the stand was originally composed of seedlings, but early in life was burned over. Some of the trees may have escaped destruction, while those that were burned sent up one or more sprouts. These seedling sprouts, except for the fact that they often occur in groups, have all the characteristics of seedlings and may be so treated.

MANAGEMENT.

METHODS OF LUMBERING.

In typical lumbering operations in paper birch, cutting begins the latter part of September or in October, after the growing season. Except in a few instances cutting is never done in summer, owing to the danger of sap staining. The trees are practically always felled with the ax, seldom with a saw. The stumps are usually 1½ or 2 feet high. For spoolwood and similar material a diameter limit of 6 inches, breasthigh, is often adopted, and wherever possible the tops are utilized to a diameter of 4 or 5 inches. For fuel, all trees over 3 inches are taken, and the tops are utilized down to 2 inches.

After the tree has been felled the method of handling varies in different localities. Sometimes the men work separately, each man taking a given area and doing all the work on that area himself. He chops down the trees, saws them into 4-foot bolts with a buck saw, marks out and clears a road as he goes, and finally piles the bolts into stacked cords along the road. These are of regular size, 8 feet long and 4 feet wide, but are made 4 feet 4 inches high to allow for the shrinking and settling of the green wood. When the men work individually in this way they are paid by the cord, usually $1.50. Under average conditions an ordinary worker will put up 1½ to 2½ cords per day, and an exceptionally good man 3 or even 4 cords. Under particularly favorable circumstances a record of 5 or 6 cords per day has been maintained for several days. This method of working is particularly adapted to dense stands of small trees.

Perhaps the more common method is by crews, in which each man is given a definite part of the work to do. One man does all the chopping, others all the sawing, and still others attend to the piling. The sawyers usually work in pairs and use a large crosscut saw, although they are also provided with individual buck saws for the smaller logs. One chopper is able to fell enough trees to keep four sawyers busy. After the trees have been cut into 4-foot bolts these are removed on low sleds, managed by a "sled tender," and then piled. No attempt is made to have the piles contain an even number of cords, and their exact contents are not known until they are measured by the scaler. Their size and location are determined wholly by convenience in making and afterwards removing them. With this method the men are paid by the day or month, and there is not so heavy a cut per man as when the men work alone. It seldom exceeds 1½ or 2 cords per day. This method is particularly adapted to stands where the logs are too large for one man to handle and where the birch is so scattered that one man could not work to advantage by himself.

A modification of the crew method is to remove the tree stems to the place where they are to be piled before cutting them into bolts. One man does all the chopping, but as soon as the trees are felled and their tops cut off they are dragged, or "twitched," to the piles and there cut into bolts by a saw crew. This is "sawing at the yard" in contrast to "sawing at the stump." It saves two handlings of the bolts, but it makes the logs very gritty as they are dragged through the dirt, with subsequent serious wear and tear on the saws at the mill.

Still another modification of the crew method is to have crews of only two or three men, in which each takes his turn at the chopping, sawing, and piling.

The wood is usually scaled and sold by the stacked cord. A stack 8 feet long, 4 feet wide, and 4 feet high is scaled as 1 cord without regard to its actual solid contents. Theoretically a cord contains 128 cubic feet, but because of the numerous air spaces the average solid content of a stacked cord of paper birch spool stock is approximately 96 cubic feet, though this varies considerably with different-sized bolts. The best way to scale birch, therefore, is not by the stacked cord, but by the cubic foot. This may be done in two ways: By measuring each stick and finding its solid contents from a table giving the contents in cubic feet of sticks of different diameters; or by estimating the average size of the sticks and obtaining the solid contents from a table giving the average contents of stacks composed of different-sized bolts (as Table 8, on page 35).

In some localities the wood is first scaled in cubic feet by the New Hampshire log rule, and this figure is then reduced to cords by considering 128 cubic feet as equal to 1 cord. The cubic foot given in the New Hampshire rule is merely an arbitrary standard and is not the true cubic foot. It is equal to the contents of a log 16 inches in diameter and 1 foot long, or actually 1.4 cubic feet. Consequently 128 of these so-called cubic feet really contain 179 cubic feet. But since 96 cubic feet make a stacked cord, a cord scaled by the New Hampshire rule is equivalent to 1.9 stacked cords. This explains why considerably higher prices are often obtained for birch bought by the New Hampshire rule than by the stacked cord.

Occasionally paper birch is cut into boards, to be later ripped up and manufactured into bobbins and shuttles. In this case it is scaled by the thousand feet, board measure, New Hampshire rule.

Birch stumpage varies from $0.75 to $2 per cord, according to its quality and location. The average price is about $1.50 per cord.

After the bolts have been cut and stacked along the logging roads, the final step in the lumbering operations is to get them to the mill. This is done on sleds when the ground is covered with snow. Sometimes only a few main roads are used, with no branches, and the bolts are all carried from their original piles and stacked along these main roads. The more usual way, however, is to pile them near where they are cut and have numerous branch roads leading to these piles. Cutting is continued until the deep snow interferes seriously with the work, when the rest of the winter is devoted to hauling. The hauling is usually done with horses and sleds. Steam log haulers are used to some extent and give good results, particularly when long hauls are necessary. Spool-bar mills are often set up near the source of supply and the bars taken from there to the spool mill. This obviates unnecessary hauling of waste in the bolts. When a railroad runs near the source of supply it is made use of; and since paper birch is heavy and difficult to handle, it is probable that the exploitation of the more remote and inaccessible areas will depend largely on the development of railroad logging.

A marked variation from the usual method of operation is in the few cases where the logs are driven or rafted to the mill. When this is done the logs are never cut into bolts in the woods, but the whole stem is put into the water. Contrary to common belief, green paper birch will float for a while, and it is sometimes put into the water in this condition. But, since seasoned wood is lighter, it is usually first seasoned to some extent. An effective method is to cut the trees in summer and leave the tops on. The leaves continue to transpire moisture for a while, with the result that a large quantity is removed from the tree at once and the wood is left in a comparatively seasoned condition. The tops may then be cut off and the stem put into the water immediately. Another method is to remove the tops at once and then let the logs stay in the woods for about a year to season. This method is probably not so effective, since birch seasons very slowly when left with the bark on. If cut in summer the logs are also likely to stain badly, at least at the ends.

It is generally thought by lumbermen that paper birch can be successfully driven short distances and remain in the water two or three weeks, but that after that it becomes waterlogged and sinks. Logs have been rafted 40 miles, however, and have remained in the water fifty or sixty days, with results good enough to warrant the drive. The amount lost depends not only on the seasoning of the wood but also on the weather conditions. Even the lightest birch floats low in the water, and during heavy winds is likely to work its way under the boom and escape. While the average loss under good weather conditions may perhaps be 10 per cent, this loss may easily be doubled by a severe storm.

Mill men differ decidedly in their opinions as to the wisdom of attempting to drive paper birch. Some think it inadvisable under any conditions; others think that under certain conditions it pays well for short distances; while still others believe in attempting long drives. Some think that driving injures the quality of the wood; others think not, and the question has not yet been studied enough to lead to any hard and fast conclusions. The one great advantage of driving over hauling is its cheapness. For distances up to 20 miles it should give good results, provided the wood is properly handled before it is put into the water. Driving is often valuable in making stands accessible which are now too remote to be lumbered in the ordinary way. In time it may be supplanted by log haulers or railroads, but at present it is a valuable method under certain conditions.

POSSIBLE IMPROVEMENTS.

Although the present methods of lumbering paper birch are, on the whole, very good and generally economical, there are a few ways in which they could be improved and more complete utilization secured. First of all, stumps should be cut lower and the trees should be felled with a saw instead of an ax. Paper birch is usually not a large tree, and the base is seldom very swell-butted, so that stumps could, in most cases, very readily be cut to a height of 1 foot; this would gain from half a foot to a foot of good material. In chopping, another half foot or more is wasted in the scarf, and could be saved by substituting sawing for chopping. The saving in the butt log through both of these means would average about 5 per cent in the largest and best part of the bole, and would also mean that frequently another bolt could be secured from the top.

A further saving could in many cases be effected in the top itself. For spool stock this should be utilized down to a diameter of 4 inches, except where numerous branches make this obviously impossible. In some cases this is already done, but in many others a large part of the top is wasted because there is a fork, or one or two large branches, above which there is still merchantable material. Not infrequently a tree forks about halfway up, and the good material above can be utilized simply by cutting out the crotch. The saving effected would vary greatly, from about 5 to more than 50 per cent, but would probably average about 20 per cent. Large branches which are now sometimes rejected could be made use of in the same way.

Whether that portion of the top which remains after the merchantable spool stock has been taken out should be used for fuel depends chiefly upon the locality. When the cutting is near a railroad or settlement it can be so used, but when it is more or less remote this is impracticable, and the tops must simply be left upon the ground. The whole question is simply one of dollars and cents—will it pay?

The cutting of young trees for fuel down to 3 inches in diameter is a distinctly bad practice. Such trees are usually growing rapidly and much greater returns can be obtained if they are left until they attain sufficient size for spoolwood, and cut to a minimum diameter of 6 inches. The tops can then be utilized for fuel and will probably yield nearly as much as the entire tree if it had been cut when only 3 inches in diameter. Immature, healthy trees should not be cut to a diameter of less than 6 inches for any purpose.

In connection with the utilization of material now wasted, the question arises whether the tops and the waste produced at the mill, such as slabs, edgings, and heart, could not be used for the manufacture of wood alcohol, acetic acid, and charcoal. There is no doubt that these products could be made from paper birch, but it is doubtful whether, under present conditions, their manufacture would prove profitable. Except under peculiarly favorable circumstances the handling of the tops is rather expensive, there is not a large amount of waste at the mill which could be utilized, and the cost of marketing the charcoal would, in many cases, be about as much as it would bring.

A more practicable form of saving lies in the direction of the more complete utilization of sound red heart. This is already used to some extent for the cheaper grades of spools and for novelties, and could doubtless be used in this way still more widely.

SYSTEMS OF MANAGEMENT.

The point to emphasize in the management of paper birch, whether pure or mixed, is that the type is preeminently a temporary one. It is the connecting link between the original permanent type of the virgin forest and the similar type which will take its place when natural conditions, now disturbed by fire or clearing, are restored. This means that a birch stand can not be replaced by a birch stand indefinitely except by planting, or, possibly, by burning over the area to bring about those conditions which first brought it into existence. This point should constantly be borne in mind, since it has an important influence on the method of cutting to be employed.

There are three distinct systems of cutting which are applicable to birch stands under different conditions: 1. Cutting to a diameter limit to utilize the young growth to the best advantage. 2. Clean cutting of pure stands to secure sprout reproduction. 3. Complete removal of birch from mixed or changing types to give way to species which are more valuable or better adapted to the locality.

1. Cutting to a diameter limit is applicable to middle-aged, pure stands, usually more or less even aged, but which show considerable variation in diameters. The object of the cutting is to free the smaller trees, which would otherwise soon be suppressed and killed out, and to leave them for a second cut ten or twenty years later. There is no intention of securing reproduction, the aim being rather to utilize the present stand to the best possible advantage. Cuttings of this sort should be made when the stand is from 40 to 50 years old, and should remove the larger trees to a diameter of 7 or 8 inches. Hard and fast rules, however, are seldom applicable, and the diameter limit should be flexible; that is, trees above the limit should be left or trees below the limit removed, as circumstances prescribe.

This method is not applicable to mature or overmature stands, even when these show a wide variation in diameters. In such cases the smaller trees are not younger, but are simply suppressed, poorly developed, and usually unthrifty trees of the same age as the rest of the stand. Opening up the stand would not materially increase their rate of growth, and the chances are that they would deteriorate or die before the next cutting. Such a stand should be cut clean and all of the merchantable material utilized.

2. Clean cutting to secure reproduction is applicable in pure, middle-aged stands, in which the trees are nearly all of the same size and in which there is no lower story of other species. Such stands usually have a considerable undergrowth of shrubs and weeds which would interfere with the growth of seedlings, but through which the more vigorous sprouts are able to shoot up and establish a new stand.

This second growth may not be as good as the original, but if the system is carefully carried out a sufficiently heavy stand to warrant a second cut is practically assured.

The cutting should be done when the trees are from 50 to 60 years old, at which age they have an average diameter of 8 or 9 inches. After this age, the sprouting capacity is feeble or entirely lacking and the reproduction scanty. Also, the rate of growth is then too slow to warrant holding the stand longer, and the amount of heartwood increases rapidly.

The resulting sprout stands may be managed by the clean-cutting system in the same way. Owing to their shorter life, however, the cutting should take place when the trees are about 40 or 50 years old, with an average diameter of 7 or 8 inches. The method can not be continued indefinitely, however, and a second, or under most favorable circumstances a third, crop is all that can be hoped for, owing to the exhaustion of the birch stumps and the encroachment of other species.

The shape and size of the cuttings are immaterial, and since sprout reproduction is depended on, the leaving of seed trees is unnecessary. There will always be trees enough near by to furnish seed for such seedlings as are able to establish themselves.

3. In all other cases the complete removal of the birch, with no provision for reproduction or a second cut, is advisable. The object is to utilize all of the birch already on the ground and at the same time to restore the type natural to the locality. This method is obviously the one to use in mixed stands of birch and conifers or birch and other hardwoods, where there is no hope of securing birch reproduction, and where the object is to favor the other trees by getting rid of the birch altogether. It is particularly advisable in the white pine belt. The same system of cutting, with the same object, is applicable to pure birch stands which are overmature or in which there is already a second story of other species ready to occupy the ground as soon as the birch is removed. In neither case can satisfactory reproduction be looked for. Overmature stands should be cut at once and younger stands at the time they will yield the greatest amount of wood of the best quality.

The best method of disposing of the débris left after lumbering in birch stands is to lop the larger branches of the tops so that they and the main trunk will come into contact with the ground. In the moist woods of the Northeast the danger of fire starting in old tops is not very great where ordinary precautions are taken, so that it is unnecessary to pile and burn them. Moreover, birch rots very quickly in contact with the soil, and these old tops and brush help to improve the humous conditions of the forest. Whether the scattering and burning of the tops as they lie on the ground might sometimes be advisable as a silvicultural measure is an open question. This method would destroy the ground cover, expose the bare mineral soil, and bring about the very conditions which first produced the birch stand. It would, therefore, be reasonable to expect a fair reproduction on such land again, particularly if natural means were supplemented by the broadcast sowing of a small amount of seed. On the other hand, this burning would in most cases destroy large numbers of seedlings of other species which had already established themselves, and would delay the ultimate occupation of the land by the natural type best suited to it. Furthermore, great care would have to be exercised to see that the fire did not escape into the surrounding forest with disastrous results. On the whole, scattering and burning of the brush seems unwise at present, or at least until paper birch is much scarcer and dearer than it is now.

VOLUME AND YIELD TABLES.

The accompanying tables show the average volume of paper birch trees. The figures can not be applied to individual trees, which often vary from 10 to 15 per cent from the average, but applied to a large number of trees will give accurate estimates. The diameters given are outside the bark. The figures are from trees in central Maine and eastern New Hampshire, localities which are representative of the paper birch region. All board feet are by the New Hampshire log rule.

Table 3 shows the total volume of trees of different diameters and heights in cubic feet. Table 4 shows the merchantable volume of trees of different diameters and heights in both cubic feet and board feet by the New Hampshire rule. Table 5 shows the merchantable volume of trees of different diameters and merchantable lengths in both cubic feet and board feet. All of these tables can be applied to either seedling or sprout growth. With trees of the same diameter average sprouts have greater height and, therefore, greater volume than average seedlings. But when they do happen to have the same diameter and also the same height, then their volume is the same. In other words, the shape of the stem is the same for both seedlings and sprouts, provided they have the same height and diameter. If the volume tables were based on diameter alone, separate tables would have to be made for seedlings and sprouts, but when both diameter and height are used in the classification they can be grouped together in one table, as is done in this case.

TABLE 3.—*Total stem volumes of paper birch, based on measurements of 443 trees.*

Diameter breast-high.	Height of tree.				
	50 feet.	60 feet.	70 feet.	80 feet.	90 feet.
	Volume.				
Inches.	*Cu. ft.*	*Cu. ft.*	*Cu. ft.*	*Cu. ft.*	*Cu. ft.*
4	2.5	3.0	....	....	....
5	3.7	4.3	4.8	....	....
6	5.2	5.9	6.7	7.8	....
7	6.8	7.8	9.0	10.4	12.2
8	8.9	10.2	11.5	13.3	15.3
9	11.2	12.8	14.5	16.5	18.8
10	14.0	15.9	18.0	20.4	22.8
11	17.2	19.5	21.8	24.6	27.5
12	20.0	23.4	26.3	29.5	33.0
13	....	28.0	31.5	35.3	39.6
14	....	33.0	37.3	42.1	47.4
15	....	38.9	44.0	49.7	55.8
16	....	....	51.0	57.5	60.0

TABLE 4.—*Merchantable volumes of paper birch, by diameter and height, based on measurements of 445 trees.*

Diameter breast-high.	Height of tree.										Diameter inside bark of top.
	50 feet.		60 feet.		70 feet.		80 feet.		90 feet.		
	Volume.										
Inches.	*Cu. ft.*	*Bd. ft.*	*Cu. ft.*	*Bd. ft.*	*Cu. ft.*	*Bd. ft.*	*Cu. ft.*	*Bd. ft.*	*Cu. ft.*	*Bd. ft.*	*Inches.*
5	2.7	16	3.2	19	3.7	23	....	....	....	....	3.3
6	3.8	22	4.6	26	5.4	30	6.2	35	....	....	3.7
7	5.2	28	6.3	34	7.3	40	8.5	46	9.6	52	4.2
8	6.8	38	8.2	45	9.5	52	11.0	60	12.4	68	4.5
9	8.7	48	10.4	57	12.2	67	14.0	76	15.5	86	4.8
10	10.9	60	13.0	72	15.2	85	17.4	95	19.3	108	5.1
11	13.4	73	16.0	88	18.8	104	21.4	117	24.0	132	5.3
12	16.3	88	19.5	106	22.8	124	26.1	141	29.3	160	5.5
13	19.8	106	23.3	127	27.3	148	31.3	169	35.0	191	5.6
14	....	....	27.7	150	32.3	176	37.0	201	41.5	226	5.8
15	....	....	32.5	177	37.8	207	43.2	236	48.5	266	5.9
16	....	....	....	206	43.8	242	50.0	276	56.3	310	6.0
17	....	....	....	....	50.3	280	58.0	320	64.9	360	6.1
18	....	....	....	....	57.4	320	....	366	....	412	6.1

Table 5.—*Merchantable volumes of paper birch, by diameter and merchantable length, based on measurements of 396 trees.*

Diameter breasthigh.	Merchantable length.													
	12 feet.		16 feet.		20 feet.		24 feet.		28 feet.		32 feet.		36 feet.	
	Volume.													
Inches.	*C.ft.*	*B.ft.*	*C.ft.*	*B.ft.*	*C.ft.*	*B.ft.*	*C.ft.*	*B.ft.*	*C.ft.*	*B.ft.*	*C.ft.*	*B.ft.*	*C.ft.*	*B.ft.*
5	1.7	7	2.0	10	2.3	13	2.6	15	2.9	18	3.2	21	......	......
6	2.4	12	2.9	16	3.4	19	3.9	22	4.3	25	4.8	28	5.4	31
7	3.3	17	3.9	21	4.6	25	5.3	29	5.9	33	6.5	37	7.2	41
8	4.2	23	5.2	28	6.0	32	6.8	37	7.6	42	8.4	47	9.2	52
9	5.3	29	6.6	34	7.5	40	8.5	46	9.5	51	10.5	57	11.4	64
10	......	35	8.1	41	9.2	48	10.3	55	11.5	61	12.7	68	13.8	76
11	......	......	......	49	11.0	56	12.2	64	13.5	71	15.0	80	16.4	89
12	......	......	......	......	......	......	......	73	15.7	82	17.5	92	19.2	103
13	......	......	......	......	......	......	......	......	......	......	20.1	105	22.7	120
14	......	......	......	......	......	......	......	......	......	......	......	118	27.0	138

Diameter breasthigh.	Merchantable length.											
	40 feet.		44 feet.		48 feet.		52 feet.		56 feet.		60 feet.	
	Volume.											
Inches.	*C.ft.*	*B.ft.*	*C.ft.*	*B.ft.*	*C.ft.*	*B.ft.*	*C.ft.*	*B.ft.*	*C.ft.*	*B.ft.*	*C.ft.*	*B.ft.*
5	......	......	......	......	......	......	......	......	......	......	......	......
6	5.8	35	6.3	......	7.0	......	......	......	......	......	......	......
7	7.9	45	8.4	49	9.3	53	9.9	57	......	......	......	......
8	10.0	57	10.8	62	11.6	67	12.4	72	13.2	76	14.0	80
9	12.3	69	13.3	75	14.2	81	15.2	86	16.1	92	17.1	98
10	14.9	83	16.0	90	17.2	97	18.4	104	19.4	111	20.6	119
11	17.8	97	19.3	107	20.7	115	22.2	124	23.6	134	25.2	142
12	21.0	114	23.0	125	24.8	137	26.7	148	28.6	160	30.6	168
13	24.9	133	27.4	146	29.8	160	32.3	174	34.9	187	37.5	200
14	30.0	154	33.0	170	35.9	185	39.1	201	41.5	......	......	......

An interesting feature of these tables is the rather high volume shown by paper birch, as compared with many other species. This is due to the fact that it has a bole which is more or less cylindrical in shape, with a small taper. This is clearly shown in Table 6. The bole is usually straight and free from branches for from 40 to 50 feet from the ground; above this there are numerous limbs and the taper is quite rapid. Table 7 shows the taper of the stump at 1-foot intervals from the ground and furnishes a means of determining the breastheight diameter of trees of different stump heights.

TABLE 6.—*Diameters of paper birch at 5-foot intervals above the ground, based on measurements of 354 trees.*

60-FOOT CLASS.

Diameter breast-high.	Height above ground.							
	5 feet.	10 feet.	15 feet.	20 feet.	25 feet.	30 feet.	35 feet.	40 feet.
	Diameter outside bark.							
Inches.	*Inches.*	*Inches.*	*Inches.*	*Inches.*	*Inches.*	*Inches.*	*Inches.*	*Inches.*
6	6.0	5.7	5.4	5.0	4.6	4.2	3.8	3.4
7	7.0	6.7	6.3	5.9	5.5	5.0	4.5	3.9
8	8.0	7.6	7.2	6.8	6.2	5.6	5.0	4.3
9	9.0	8.5	8.1	7.6	7.0	6.3	5.5	4.7
10	10.0	9.5	8.9	8.4	7.7	7.0	6.1	5.2
11	10.9	10.4	9.8	9.2	8.5	7.7	6.8	5.7
12	11.9	11.3	10.6	10.0	9.3	8.4	7.5	6.4
13	12.9	12.2	11.5	10.8	10.0	9.2	8.2	7.1

70-FOOT CLASS.

Diameter breast-high.	Height above ground.									
	5 feet.	10 feet.	15 feet.	20 feet.	25 feet.	30 feet.	35 feet.	40 feet.	45 feet.	50 feet.
	Diameter outside bark.									
Inches.	*Inches.*	*Inches.*	*Inches.*	*Inches.*	*Inches.*	*Inches.*	*Inches.*	*Inches.*	*Inches.*	*Inches.*
6	6.0	5.9	5.7	5.4	5.1	4.6	4.3	3.9	3.5	3.1
7	7.0	6.7	6.5	6.1	5.8	5.3	5.0	4.5	4.0	3.5
8	8.0	7.6	7.3	6.9	6.5	6.0	5.6	5.1	4.5	3.9
9	8.9	8.5	8.1	7.7	7.2	6.7	6.2	5.7	5.0	4.3
10	9.9	9.4	9.0	8.5	8.0	7.4	6.9	6.2	5.5	4.7
11	10.9	10.3	9.9	9.3	8.8	8.2	7.5	6.8	6.0	5.1
12	11.9	11.3	10.8	10.2	9.6	8.9	8.2	7.5	6.5	5.5
13	12.9	12.2	11.7	11.1	10.5	9.7	9.0	8.1	7.1	5.9
14	13.9	13.2	12.6	12.0	11.3	10.6	9.7	8.8	7.6	6.4

80-FOOT CLASS.

Diameter breast-high.	Height above ground.											
	5 feet.	10 feet.	15 feet.	20 feet.	25 feet.	30 feet.	35 feet.	40 feet.	45 feet.	50 feet.	55 feet.	60 feet.
	Diameter outside bark.											
Inches.	*In.*	*In.*	*In.*	*In.*	*In.*	*In.*	*In.*	*In.*	*In.*	*In.*	*In.*	*In.*
7	7.0	6.8	6.6	6.4	6.2	5.9	5.6	5.2	4.7	4.1	3.5	2.9
8	8.0	7.7	7.4	7.2	6.9	6.5	6.1	5.7	5.2	4.6	3.9	3.3
9	8.9	8.6	8.3	8.0	7.6	7.1	6.7	6.3	5.7	5.1	4.4	3.7
10	9.9	9.5	9.2	8.8	8.3	7.8	7.3	6.9	6.3	5.6	4.8	4.0
11	10.9	10.5	10.1	9.6	9.2	8.6	8.1	7.5	6.9	6.1	5.3	4.4
12	11.9	11.4	11.0	10.5	10.0	9.4	8.8	8.2	7.5	6.7	5.7	4.8
13	12.9	12.4	11.9	11.4	10.9	10.3	9.7	8.9	8.1	7.2	6.2	5.1
14	13.9	13.3	12.8	12.3	11.8	11.2	10.5	9.6	8.8	7.8	6.7	5.5

Table 7.—*Diameters of paper birch at 1-foot intervals above the ground below breastheight, based on measurements of 300 trees.*

Diameter breast-high.	Height from ground.			
	1 foot.	2 feet.	3 feet.	4 feet.
	Diameter outside bark.			
Inches.	*Inches.*	*Inches.*	*Inches.*	*Inches.*
3	3. 5	3. 2	3. 1	3. 0
4	4. 8	4. 3	4. 1	4. 0
5	6. 0	5. 5	5. 2	5. 1
6	7. 2	6. 6	6. 2	6. 1
7	8. 4	7. 7	7. 3	7. 1
8	9. 9	8. 9	8. 3	8. 1
9	11. 4	10. 0	9. 4	9. 2
10	12. 8	11. 2	10. 4	10. 2
11	14. 1	12. 3	11. 5	11. 2
12	15. 4	13. 4	12. 6	12. 3
13	16 6	14. 5	13. 6	13. 3
14	17. 8	15. 5	14. 7	14. 3
15	18. 9	16. 6	15. 7	15. 3
16	20. 1	17. 6	16. 8	16. 3

The amount of solid wood in a stacked cord is influenced by many factors, such as form, diameter, and length of sticks, and method of stacking. Table 8 is based on measurements of 16 half-cord stacks of unseasoned paper birch spoolwood bolts in the round and shows the influence of diameter on the solid contents of the stack. The measurements show the high average of 96 cubic feet per cord for spoolwood bolts averaging from 5 to 12 inches in diameter, which indicates very clearly that most birch bolts are smooth and straight. Ninety-six cubic feet may therefore be assumed as equivalent to one cord and, with modification depending on the average size of the sticks, used as a converting factor in changing volumes from one measure into the other.

The proportion of sap and heartwood varies more or less irregularly with bolts of different sizes. While the larger bolts contain absolutely more heart than the smaller ones, they may not contain any more relatively. The measurements show the average per cent of heart to be 6.9 per cent, and of sapwood 82.7 per cent. In spite of the fact that birch bark is relatively thin, it averages as high as 10.4 per cent of the total volume, and does not show any regular variation with changes in the size of the sticks.

The fuel wood is small, knotty, often quite crooked, and does not pack closely. Measurements of two half-cord stacks showed the high average of 274 sticks per cord, with the correspondingly small average solid contents of only 65.5 cubic feet per cord.

TABLE 8.—*Solid contents per stacked cord for paper birch spoolwood bolts of different diameters, in the round.*

Average diameter of stick.	Sticks per cord.	Solid wood per cord.
Inches.	*Number.*	*Cu. ft*
5	135	82.0
6	106	86.7
7	85	91.4
8	69	96.0
9	57	100.0
10	47	102.8
11	39	104.6
12	32	105.2

Table 9 shows the yield of pure paper birch stands at different ages and in different situations. The best situations are designated as quality 1, the medium situations as quality 2, and the poorest situations as quality 3. Figures are given only for qualities 1 and 2. The situations in which birch is found throughout the region probably average slightly better than quality 2. The yields given were obtained by a field party under R. L. Marston, of the Forest Service, from 46 sample plots of different ages, all of which contained at least 40 per cent birch and had a density of over 50 per cent. Where the plots contained other species in mixture the figures were reduced to correspond to a pure (100 per cent) birch stand. Hence the table applies only to pure birch stands of average density (83 per cent in quality 1, and 75 per cent in quality 2). For a mixed stand containing, for example, 60 per cent of birch, a corresponding reduction would have to be made in the yield.

TABLE 9.—*Yield per acre of pure paper birch stands of average density.*

QUALITY 1.

Age.	Average diameter breast-high.	Average height.	Total yield.		Annual rate of growth.	Yield of trees 6 inches and over in per cent of total yield.
Years.	*Inches.*	*Feet.*	*Cu. ft.*	*Cords.*	*Per cent.*	*Per cent.*
15	2.3	24	710	7.4	9.0	....
20	3.4	33	1,020	10.6	6.2	4
25	4.5	41	1,340	14.0	5.1	27
30	5.6	48	1,700	17.7	4.5	46
35	6.4	54	2,090	21.8	3.9	63
40	7.2	58	2,520	26.2	3.3	75
45	7.8	62	2,950	30.7	2.7	85
50	8.4	65	3,340	34.8	2.1	91
55	8.8	68	3,660	38.1	1.5	96
60	9.2	70	3,940	41.0	1.0	98
65	9.6	72	4,190	43.6	.7	100
70	10.0	74	4,450	46.4	.6	100
QUALITY 2.						
15	1.8	21	410	4.3	8.0	....
20	2.6	28	580	6.0	6.2	....
25	3.4	34	770	8.0	5.6	18
30	4.3	40	1,010	10.5	5.0	35
35	5.0	45	1,290	13.4	4.4	50
40	5.7	49	1,580	16.5	3.9	63
45	6.3	53	1,890	19.7	3.4	73
50	6.8	56	2,220	23.1	2.9	82
55	7.2	59	2,530	26.4	2.4	89
60	7.6	61	2,810	29.3	1.9	94
65	7.9	64	3,060	31.8	1.6	97
70	8.2	66	3,300	34.4	1.4	100

Although the total stem volume is given in Table 9, the lowest measurement taken in the sample trees was at 4½ feet, and the disregard of butt swelling makes the yield conservative. The yield in cubic feet was reduced to cords by dividing by 96, as previously explained. To reduce the total yield to merchantable volume the figures given would have to be reduced in general from 20 per cent to 30 per cent. The annual rate of growth in volume for the whole stand, as shown in Table 9, is less than the rate of growth of individual trees shown in Table 2. This is largely due to the fact that in measuring the individual trees the very smallest were not included, while in measuring the stand even the smallest, suppressed trees were measured whether they were merchantable or not. After twenty years of age the rate of growth in quality 1 stands is less than that in quality 2, although their actual volume growth continues to be considerably greater. This is due to their quicker growth in early youth and to their greater volume at all ages throughout the life of the stand.

These measurements were all taken in unmanaged stands just as they occurred in the forest, and show what may be expected from natural birch stands. Where the stands are near settlements and easily accessible, the yield can be increased by thinnings, which not only utilize the smaller and less desirable trees but also increase the growth of those that remain.

OUTLOOK FOR FUTURE SUPPLIES.

Forest conditions and forest policies are now changing so rapidly that it is difficult to predict what conditions will prevail many years in the future. In the case of paper birch, however, it seems fairly certain that for a good many years the supply will not be exhausted. There are extensive areas of mature birch which should be cut as soon as possible, and there are also considerable stands of young material of various ages which will later be available. Future supplies will be brought from greater and greater distances and from places now inaccessible, as better transportation facilities and an increase in the value of birch eventually bring them to market. These future supplies will undoubtedly come largely from Maine and New Hampshire. The Lake States, particularly Minnesota, may in time furnish a small supply, but the bulk of the material will still come from the Northeast.

Whether the supply of paper birch will last indefinitely is a much more difficult question. As already stated, paper birch represents a distinctly transitory forest type, and the present stands are bound to be replaced, in time, by the types natural to the locality. Fires and clearings give birch a chance to reoccupy old areas and seize upon new ones, but with the prevention of forest fires and the more permanent occupancy of agricultural lands these factors will be less influential in the future. Extensive stands of paper birch may, therefore, tend to become scarcer and scarcer, but it is very doubtful whether they will ever disappear altogether. Clearings of one sort or another will enable it to get a footing, and the passing of the paper birch is too remote a contingency to be accurately foretold.

Approved:
James Wilson,
Secretary of Agriculture.

Washington, D. C., *March 22, 1909.*

O